What is claimed is:

1. A method of improving a shape of a high-precision surface, comprising the steps of:

a) providing a material with an initial shape on at least one face thereof;

b) measuring errors in the initial shape of the high-precision surface, the errors being deviations from a desired shape; and

c) correcting the errors in the initial shape of the high-precision surface by selectively applying pulses of light from a laser to the errors to ablate the deviations.

2. The method of claim 1, wherein the step of providing a material with an initial shape on the at least one face includes the step of providing a material with a substantially flat shape.

3. The method of claim 1, wherein the errors measured in step (b) include one or more undulations.

4. The method of claim 1, wherein the errors measured in step (b) include mechanical processing marks.

5. The method of claim 1, wherein step (b) includes using at least one of a laser interferometer, white light interferometer, a linear variable displacement transducer, a scanning probe microscopy, a scanning tunneling microscope, an atomic force microscope, a near-field scanning optical microscope, or a shear-force microscope on the high-precision surface to measure the deviations from the desired shape.

6. The method of claim 1, wherein:

step (b) includes determining a pulse schedule based on the errors in the initial shape; and

step (c) includes moving a beam spot of the laser along a predetermined path over the at least one face of the surface and selectively permitting the pulses of light to irradiate portions of the surface according to the pulse schedule.

7. The method of claim 1, wherein:

step (b) includes determining a pulse schedule based on the errors in the initial shape; and

step (c) includes moving the material so that the at least one face passes through a beam path of the laser, and selectively permitting the pulses of light to irradiate portions of the surface according to the pulse schedule.

8. A method according to claim 1, wherein:

the shape is a substantially circularly symmetric feature; and

step (c) includes the steps of:

c1) moving a beam spot of the laser along a perimeter of the substantially circularly symmetric feature in one of a clockwise direction or a

counterclockwise direction at a rate of spin;

c2) irradiating the high-precision surface along the perimeter of the feature with the pulses of light, at a pulse frequency selected such that centers of ablated regions from consecutively applied pulses are separated by a predetermined circumferential distance;

c3) repeating steps (c1) and (c2) until the errors along the perimeter of the substantially circularly symmetric feature are substantially corrected;

c4) radially moving the beam spot of laser by a predetermined radial distance to one of a smaller perimeter or a larger perimeter of the substantially circularly symmetric feature; and

c5) repeating steps (c1), (c2), (c3), and (c4) until the errors of the initial shape are substantially corrected.

9. A method according to claim 1, wherein:

the shape is a substantially circularly symmetric feature; and

step (c) includes the steps of;

c1) moving the material so that a perimeter of the substantially circularly feature passes through a beam spot of the laser in one of a clockwise direction or a counterclockwise direction at a rate of spin;

c2) permitting the laser to pulse at a pulse frequency to apply pulses along the perimeter of the substantially circularly symmetric feature, wherein centers of ablated regions from consecutively applied pulses are separated by a predetermined circumferential distance;

c3) repeating steps (c1) and (c2) until the errors along the perimeter of the substantially circularly symmetric feature are substantially corrected;

c4) radially moving the material by a predetermined radial distance to one of a smaller or a larger perimeter of the substantially circularly symmetric feature; and

c5) repeating steps (c1), (c2), (c3), and (c4) until the errors of the initial shape are substantially corrected.

10. A method according to claim 1, wherein step (c) includes maintaining a predetermined angle of incidence of the pulses of light from the laser on one of:

the initial shape; or

the at least one face.

11. A method according to claim 1, wherein the step (c) includes activating the laser such that the pulses of light generated have a duration less than or equal to 1 nanosecond.

12. A method of improving a shape of a high-precision mold, comprising the

steps of:

a) providing a block of mold material with an initial shape formed on at least a face thereof;

b) forming a thin film layer over the at least a face of the block of mold material;

c) measuring errors on a surface of the thin film formed over at least the initial shape, the errors being deviations from a desired mold shape; and

d) correcting errors on the surface of the thin film by selectively applying pulses of light from an ultrafast laser to the errors to ablate the deviations.

13. The method of claim 12, wherein:

step (a) includes providing mold material in which the initial shape includes a cavity formed on the at least a face, the mold material including at least one of: tungsten-carbide; sapphire; a solid state carbon material; Al_2O_3; Cr_2O_3; SiC; ZrO_2; Si_3N_4; TiN; TiC; BN; Ni; Cr; Ti; W; Ta; Si; glass; a cermet incorporating at least one of TiN, TiC, Cr_3C_2, or Al_2O_3; or an alloy incorporating at least one of Ni, Cr, Ti, W, Ta, or Si, and

step (b) includes applying a metal or alloy including at least one of nickel, titanium, niobium, vanadium, molybdenum, platinum, palladium, iridium, rhodium, osmium, ruthenium, rhenium, tungsten, or tantalum.

14. The method of claim 12, wherein the errors measured in step (c) include one or more undulations.

15. The method of claim 12, wherein the errors measured in step (c) include mechanical processing marks.

16. The method of claim 12, wherein step (c) includes using at least one of a laser interferometer, white light interferometer, a linear variable displacement transducer, a scanning probe microscopy, a scanning tunneling microscope, an atomic force microscope, a near-field scanning optical microscope, or a shear-force microscope on the high-precision surface to measure the deviations from the desired shape.

17. The method of claim 12, wherein:

step (c) includes determining a pulse schedule based on the errors on the surface of the thin film; and

step (d) includes moving a beam spot of the laser along a predetermined path over the surface of the thin film and selectively permitting the pulses of light to irradiate portions of the surface that include the errors according to the pulse schedule.

18. The method of claim 12, wherein:

step (c) includes determining a pulse schedule based on the errors on the surface of the thin film; and

step (d) includes moving the block of mold material so that the surface of the thin film formed over at least the initial shape passes through a beam path of the laser and selectively permitting the pulses of light to irradiate portions of the surface that include the errors according to the pulse schedule.

19. A method according to claim 12, wherein:

the shape is a substantially circularly symmetric feature; and

step (d) includes the steps of:

(d1) moving a beam spot of the laser along a perimeter of the substantially circularly symmetric feature in one of a clockwise and counterclockwise direction at a rate of spin;

(d2) permitting the laser to pulse at a pulse frequency to apply the pulses of light along the perimeter of the substantially circularly symmetric feature, wherein centers of ablated regions from consecutively applied pulses are separated by a predetermined circumferential distance;

(d3) repeating steps (d1) and (d2) until the errors along the perimeter of the substantially circularly symmetric feature are substantially corrected;

(d4) radially moving the laser by a predetermined distance to one of a smaller and larger perimeter of the substantially circularly symmetric feature; and

(d5) repeating steps (d1), (d2), (d3), and (d4) until the errors on the surface of the thin film formed over at least the initial shape are substantially corrected.

20. A method according to claim 12, wherein:

the shape is a substantially circularly symmetric feature; and

step (d) includes the steps of:

(d1) moving the block of mold material so that a perimeter of the substantially circularly feature passes through a beam spot of the laser in one of a clockwise direction or a counterclockwise direction at a rate of spin;

(d2) permitting the laser to pulse at a pulse frequency to apply the pulses of light along the perimeter of the substantially circularly symmetric feature, wherein centers of ablated regions from consecutively applied pulses are separated by a predetermined circumferential distance;

(d3) repeating steps (d1) and (d2) until the errors along the perimeter of the substantially circularly symmetric feature are substantially corrected;

(d4) radially moving the block of mold material by a predetermined distance to one of a smaller and larger perimeter of the substantially circularly symmetric feature; and

(d5) repeating steps (d1), (d2), (d3), and (d4) until the errors on the surface of the thin film formed over at least the initial shape are substantially corrected.

21. A method according to one of claims 19 or 20, wherein step (d) further includes at least one of:

varying the pulse frequency at each perimeter to maintain the predetermined circumferential distance between the centers of the ablated regions from consecutively applied pulses; or

varying the rate of spin of the beam spot at each perimeter to maintain the predetermined circumferential distance between the centers of the ablated regions from consecutively applied pulses.

22. A method according to claim 12, wherein step (d) includes maintaining a predetermined angle of incidence of the pulses of light from the laser and one of the initial shape, the at least one face, or the surface of the thin film.

23. A method according to one of claims 1 or 12, wherein, step (a) includes at least one of:

placing the material in an assist gas, or

blowing the assist gas over the at least one face of the material.

24. A method of making a high-precision lens, comprising the steps of:

a) providing a lens having an initial lens shape;

b) measuring errors on a surface of the lens, the errors being deviations from a desired lens shape; and

c) correcting errors on the surface of the lens by selectively applying pulses of light from an ultrafast laser to the errors to ablate the deviations.

25. The method of claim 24, wherein step (b) includes using at least one of a laser interferometer, white light interferometer, a linear variable displacement transducer, a scanning probe microscopy, a scanning tunneling microscope, an atomic force microscope, a near-field scanning optical microscope, or a shear-force microscope on the surface of the lens to measure the deviations from the desired lens shape.

26. The method of claim 24, wherein:

step (b) includes determining a pulse schedule based on the errors in the initial lens shape; and

step (c) includes moving a beam spot of the laser along a predetermined path over the surface of the lens and selectively permitting the pulses of light to irradiate portions of the surface of the lens according to a pulse schedule.

27. The method of claim 24, wherein:

step (b) includes determining a pulse schedule based on the errors in the initial lens shape; and

step (c) includes moving the lens so that the surface of the lens passes through a beam path of the laser, and selectively permitting the pulses of light to irradiate portions

of the surface of the lens according to a pulse schedule.

28. A method according to one of claims 6, 7, 17, 18, 26, or 27, wherein the pulse schedule is determined such that a bite distance is less than or equal to one half of a length of a region ablated by one pulse of light.

29. A method according to claim 24, wherein:

the desired lens shape is a substantially circularly symmetric feature; and

step (c) includes the steps of:

(c1) moving a beam spot of the laser along a perimeter of the substantially circularly symmetric feature in one of a clockwise and counterclockwise direction at a rate of spin;

(c2) permitting the laser to pulse at a pulse frequency to apply the pulses of light along the perimeter of the substantially circularly symmetric feature, wherein centers of ablated regions from consecutively applied pulses are separated by a predetermined circumferential distance;

(c3) repeating steps (c1) and (c2) until the errors along the perimeter of the substantially circularly symmetric feature are substantially corrected;

(c4) radially moving the laser by a predetermined distance to one of a smaller and larger perimeter of the substantially circularly symmetric feature; and

(c5) repeating steps (c1), (c2), (c3), and (c4) until the errors on the surface of the lens are substantially corrected.

30. A method according to claim 24, wherein:

the desired lens shape is a substantially circularly symmetric feature; and

step (c) includes the steps of:

(c1) moving the lens so that a perimeter of the substantially circularly feature passes through a beam spot of the laser in one of a clockwise direction or a counterclockwise direction at a rate of spin;

(c2) permitting the laser to pulse at a pulse frequency to apply the pulses of light along the perimeter of the substantially circularly symmetric feature, wherein centers of ablated regions from consecutively applied pulses are separated by a predetermined circumferential distance;

(c3) repeating steps (c1) and (c2) until the errors along the perimeter of the substantially circularly symmetric feature are substantially corrected;

(c4) radially moving the lens by a predetermined distance to one of a smaller and larger perimeter of the substantially circularly symmetric feature; and

(c5) repeating steps (c1), (c2), (c3), and (c4) until the errors on the surface of the lens are substantially corrected.

31. A method according to one of claims 8, 9, 29, or 30, wherein step (c)

further includes at least one of:

varying the pulse frequency at each perimeter to maintain the predetermined circumferential distance between the centers of the ablated regions from consecutively applied pulses; or

varying the rate of spin of the beam spot at each perimeter to maintain the predetermined circumferential distance between the centers of the ablated regions from consecutively applied pulses.

32. A method according to one of claims 8, 9, 19, 20, 29, or 30, wherein the predetermined circumferential distance is less than or equal to one half of a diameter of the ablated regions.

33. A method according to claim 24, wherein step (c) includes maintaining a predetermined angle of incidence of the pulses of light from the laser and the initial lens shape.

34. A method according to claim 24, wherein, step (a) includes at least one of:

placing the lens in an assist gas, or

blowing the assist gas over the surface of the lens.

35. A method according to one of claims 23 or 34, wherein step (c) includes selectively applying the pulses of light from the laser to chemically activate the assist gas over the errors, thereby ablating the deviations.

36. A method according to one of claims 23 or 34, wherein the assist gas includes at least one of N_2, Ar, O_2, air, CF_4, Cl, H_2, or SF_6.

37. A laser machining system for improving a shape of a high-precision surface of a device by ablating device material from portions of the high-precision surface that deviate from a predetermined surface design shape, comprising:

a pulsed laser source for generating a plurality of pulses of laser light, each pulse of laser light having a predetermined peak wavelength, a pulse energy equal to a machining energy level, and a predetermined pulse width less than about 1ns;

a shutter aligned in a beam path of the plurality of pulses of laser light;

optics aligned in the beam path to focus the plurality of pulses of laser light to a beam spot;

a device mount to hold and controllably move the device such that the beam spot is scanned over the high-precision surface of the device, the device mount including;

three orthogonal linear translation stages;

a Θ rotational stage coupled to the three orthogonal linear translation stages to rotate the device about a Θ axis orthogonal to a direction of propagation of the plurality of pulses of laser light at the beam spot, the Θ

rotational stage allowing rotation of the device through an angle of substantially 180°;

a Φ rotational stage coupled to the Θ rotational stage to rotate the device about a Φ axis orthogonal to the Θ axis, the Φ axis varying as the Θ rotational stage is rotated; and

a holder coupled to the Φ rotational stage to hold the device; and

a processor to control;

the pulse energy of the plurality of pulses of laser light at the machining energy level and a diameter of the beam spot such that each pulse of laser light ablates an ablation depth of device material from the high-precision surface; and

the shutter and the device mount such that the portions of the high-precision surface that deviate from the predetermined surface design shape are irradiated by the plurality of laser pulses.

38. A laser machining system according to claim 37, wherein the pulsed laser source includes:

a pulsed laser oscillator to produce a plurality of initial pulses of laser light having a fundamental peak wavelength, the fundamental peak wavelength being longer than the predetermined peak wavelength; and

a harmonic generation crystal to generate the plurality of pulses of laser light from the plurality of initial pulses of laser light.

39. A laser machining system according to claim 37, wherein the pulsed laser source includes:

a pulsed laser oscillator to produce the plurality of pulses of laser light having a predetermined initial pulse energy; and

an attenuator coupled to the processor to control the pulse energy of the plurality of pulses of laser light at the machining energy level.

40. A laser machining system according to claim 37, wherein the pulsed laser source includes at least one of:

a Cr:YAG solid state laser oscillator;

a Cr:Forsterite solid state laser oscillator;

a Nd:YAG solid state laser oscillator;

a Nd:YVO_4 solid state laser oscillator;

a Nd:$GdVO_4$ solid state laser oscillator;

a Nd:YLF solid state laser oscillator;

a Nd:glass solid state laser oscillator;

an Yb:YAG solid state laser oscillator;

a Cr:LiSAF solid state laser oscillator;

a Ti:Sapphire solid state laser oscillator;

a Pr:YLF solid state laser oscillator;

a XeCl excimer laser oscillator;

a KrF excimer laser oscillator;

an ArF excimer laser oscillator;

a F_2 excimer laser oscillator;

a 7-diethylamino-4-methylcoumarin dye laser oscillator;

a benzoic acid, 2-[6-(ethylamino)-3-(ethylimino)-2,7-dimethyl-3H-xanthen-9-yl]-ethyl ester, monohydrochloride dye laser oscillator;

a 4-dicyanmethylene-2-methyl-6-(p-dimethylaminostyryl)-4H -pyran dye laser oscillator; or

a 2-(6-(4-dimethylaminophenyl)-2,4-neopentylene-1,3,5-hexatrienyl)-3-methylbenzothiazolium perchlorate dye laser oscillator.

41. A laser machining system according to claim 37, wherein the predetermined pulse width of the pulsed laser source is less than about 50ps.

42. A laser machining system according to claim 37, wherein the pulsed laser source generates the plurality of pulses of laser light with a repetition rate of at least about 1kHz.

43. A laser machining system according to claim 42, wherein the repetition rate of the plurality of pulses of laser light is at least about 20kHz.

44. A laser machining system according to claim 42, wherein the shutter includes a high speed electro-optical pulse picker having a switching time less than the inverse of the repetition rate of the plurality of pulses of laser light, thereby allowing individual pulses of the plurality of pulses to be selectively transmitted or blocked responsive to the processor.

45. A laser machining system according to claim 44, wherein the high speed electro-optical pulse picker is one of:

a Pockels cell pulse picker;

a Mach-Zehnder pulse picker;

a Kerr cell pulse picker;

a liquid crystal pulse picker; or

an electroabsorption pulse picker.

46. A laser machining system according to claim 44, wherein the processor controls the high speed electro-optical pulse picker to:

selectively transmit every n^{th} pulse of the plurality of pulses of laser light, where n is a positive integer; and

block other pulses of the plurality of pulses;

whereby an effective repetition rate of pulses of laser light, equal to the repetition rate divided by n, irradiate the high-precision surface.

47. A laser machining system according to claim 46, wherein, the processor controls the device mount such that a scan rate of the beam spot over the high-precision surface of the device is less than one half of the diameter of the beam spot times the effective repetition rate with which pulses of laser light irradiate the high-precision surface.

48. A laser machining system according to claim 46, wherein the processor controls the diameter of the beam spot such that a scan rate of the beam spot over the high-precision surface of the device is less than one tenth of the diameter of the beam spot times the effective repetition rate with which pulses of laser light irradiate the high-precision surface.

49. A laser machining system according to claim 44, wherein:

each of the three orthogonal linear translation stages of the device mount includes a linear position sensor electrically coupled to the processor to sense a linear position of the corresponding linear translation stage;

the Θ rotational stage of the device mount includes a Θ position sensor electrically coupled to the processor to sense a Θ position of the Θ rotational stage;

the Φ rotational stage of the device mount includes a Φ position sensor electrically coupled to the processor to sense a Φ position of the Φ rotational stage;

the processor determines a scan location of the beam spot on the high-precision surface of the device based on the predetermined surface design shape, the three orthogonal linear positions sensed by the three linear position sensors, the Θ position sensed by the Θ position sensor, and the Φ position sensed by the Φ position sensor; and

the processor controls the high speed electro-optical pulse picker to:

selectively transmit pulses of the plurality of pulses of laser light when the scan location is on one of the portions of the high-precision surface that deviate from the predetermined surface design shape; and

block pulses of the plurality of pulses when the scan location is on other portions of the high-precision surface.

50. A laser machining system according to claim 42, wherein, the processor controls the device mount such that a scan rate of the beam spot over the high-precision surface of the device is less than one half of the diameter of the beam spot times the repetition rate.

51. A laser machining system according to claim 42, wherein the processor controls the diameter of the beam spot such that a scan rate of the beam spot over the

high-precision surface of the device is less than one tenth of the diameter of the beam spot times the repetition rate.

52. A laser machining system according to claim 37, wherein:

the optics include a multi-position in situ diagnostics shuttle, an objective lens mounted on the multi-position in situ diagnostics shuttle, and a forward-facing beam alignment camera mounted on the multi-position in situ diagnostics shuttle;

the multi-position in situ diagnostics shuttle is arranged such that;

in a first shuttle position, the objective lens is aligned in the beam path to focus the plurality of pulses of laser light to the beam spot; and

in a second shuttle position, the forward-facing beam alignment camera is aligned collinear to the beam path and images an ablated area on the high precision surface of the device corresponding to a location of the beam spot when the multi-position in situ diagnostics shuttle is in the first position to produce an alignment image; and

the processor determines initial beam alignment based on the alignment image and controls the shutter and the device mount to irradiate area of the high-precision surface with the plurality of laser pulses using the initial beam alignment.

53. A laser machining system according to claim 52, wherein:

the objective lens and the forward-facing beam alignment camera are mounted on the multi-position in situ diagnostics shuttle along a shuttle translation line that is substantially parallel to the Θ axis of the Θ rotational stage of the device mount and substantially perpendicular to the direction of propagation of the plurality of pulses of laser light at the beam spot; and

the multi-position in situ diagnostics shuttle moves between the first shuttle position and the second shuttle position by moving along the shuttle translation line.

54. A laser machining system according to claim 52, wherein:

the optics further include a backward-facing beam quality camera mounted on the multi-position in situ diagnostics shuttle; and

the multi-position in situ diagnostics shuttle is arranged such that, in a third shuttle position, the backward-facing beam quality camera is aligned collinear to the beam path and images a cross-section of at least one of the plurality of pulses of laser light to obtain a measure of beam quality.

55. A laser machining system according to claim 54, wherein:

the backward-facing beam quality camera mounted on the multi-position in situ diagnostics shuttle along the shuttle translation line; and

the multi-position in situ diagnostics shuttle moves between the first shuttle position, the second shuttle position, and the third shuttle position by moving along the

shuttle translation line.

56. A laser machining system according to claim 52, wherein:

each of the three orthogonal linear translation stages of the device mount includes a linear position sensor electrically coupled to the processor to sense a linear position of the corresponding linear translation stage;

the Θ rotational stage of the device mount includes a Θ position sensor electrically coupled to the processor to sense a Θ position of the Θ rotational stage;

the Φ rotational stage of the device mount includes a Φ position sensor electrically coupled to the processor to sense a Φ position of the Φ rotational stage;

the processor determines a scan location of the beam spot on the high-precision surface of the device based on the predetermined surface design shape, the initial beam alignment, the three orthogonal linear positions sensed by the three linear position sensors, the Θ position sensed by the Θ position sensor, and the Φ position sensed by the Φ position sensor;

the processor controls the device mount to scan the beam spot over the portions of the high-precision surface that deviate from the predetermined surface design shape; and

the processor controls the shutter to transmit pulses of the plurality of pulses of laser light when the scan location is on one of the portions of the high-precision surface that deviate from the predetermined surface design shape.

57. A laser machining system according to one of claims 37 or 52, further comprising, polarization control means aligned in the beam path to control a polarization of the plurality of pulses of laser light.

58. A laser machining system according to claim 57, wherein the polarization control means control the polarization of the plurality of pulses of laser light such that the pulses are substantially circularly polarized in the beam spot.

59. A laser machining system according to claim 57, wherein:

each of the three orthogonal linear translation stages of the device mount includes a linear position sensor electrically coupled to the processor to sense a linear position of the corresponding linear translation stage;

the Θ rotational stage of the device mount includes a Θ position sensor electrically coupled to the processor to sense a Θ position of the Θ rotational stage;

the Φ rotational stage of the device mount includes a Φ position sensor electrically coupled to the processor to sense a Φ position of the Φ rotational stage;

the processor determines an angle of incidence of the pulses of laser light with the high-precision surface based on the predetermined surface design shape, the three orthogonal linear positions sensed by the three linear position sensors, the Θ position

sensed by the Θ position sensor, and the Φ position sensed by the Φ position sensor; and

the processor further controls the polarization control means to adjust the polarization of the plurality of pulses of laser light such that the pulses are elliptically polarized in the beam spot with a major polarization axis orientation and an ellipticity of the polarization selected to reduce stimulated Wood anomalies from ablation of the high-precision surface based on the angle of incidence of the pulses of laser light with the high-precision surface.

60. A laser machining system according to claim 57, wherein:

each of the three orthogonal linear translation stages of the device mount includes a linear position sensor electrically coupled to the processor to sense a linear position of the corresponding linear translation stage;

the Θ rotational stage of the device mount includes a Θ position sensor electrically coupled to the processor to sense a Θ position of the Θ rotational stage;

the Φ rotational stage of the device mount includes a Φ position sensor electrically coupled to the processor to sense a Φ position of the Φ rotational stage;

the processor determines an angle of incidence of the pulses of laser light with the high-precision surface based on the predetermined surface design shape, the initial beam alignment, the three orthogonal linear positions sensed by the three linear position sensors, the Θ position sensed by the Θ position sensor, and the Φ position sensed by the Φ position sensor; and

the processor further controls the polarization control means to adjust the polarization of the plurality of pulses of laser light such that the pulses are elliptically polarized in the beam spot with a major polarization axis orientation and an ellipticity of the polarization selected to reduce stimulated Wood anomalies from ablation of the high-precision surface based on the angle of incidence of the pulses of laser light with the high-precision surface.

61. A laser machining system according to claim 52, wherein:

each of the three orthogonal linear translation stages of the device mount includes a linear position sensor electrically coupled to the processor to sense a linear position of the corresponding linear translation stage;

the Θ rotational stage of the device mount includes a Θ position sensor electrically coupled to the processor to sense a Θ position of the Θ rotational stage;

the Φ rotational stage of the device mount includes a Φ position sensor electrically coupled to the processor to sense a Φ position of the Φ rotational stage;

the processor determines an angle of incidence of the pulses of laser light with the high-precision surface based on the predetermined surface design shape, the initial

beam alignment, the three orthogonal linear positions sensed by the three linear position sensors, the Θ position sensed by the Θ position sensor, and the Φ position sensed by the Φ position sensor; and

the processor controls the device mount to maintain the angle of incidence at substantially 0° as the beam spot is scanned over the portions of the high-precision surface that deviate from the predetermined surface design shape.

62. A laser machining system according to claim 37, wherein:

each of the three orthogonal linear translation stages of the device mount includes a linear position sensor electrically coupled to the processor to sense a linear position of the corresponding linear translation stage;

the Θ rotational stage of the device mount includes a Θ position sensor electrically coupled to the processor to sense a Θ position of the Θ rotational stage;

the Φ rotational stage of the device mount includes a Φ position sensor electrically coupled to the processor to sense a Φ position of the Φ rotational stage;

the processor determines a scan location of the beam spot on the high-precision surface of the device based on the predetermined surface design shape, the three orthogonal linear positions sensed by the three linear position sensors, the Θ position sensed by the Θ position sensor, and the Φ position sensed by the Φ position sensor;

the processor controls the device mount to scan the beam spot over the portions of the high-precision surface that deviate from the predetermined surface design shape; and

the processor controls the shutter to selectively transmit pulses of the plurality of pulses of laser light when the scan location is on one of the portions of the high-precision surface that deviate from the predetermined surface design shape.

63. A laser machining system according to claim 37, wherein:

each of the three orthogonal linear translation stages of the device mount includes a linear position sensor electrically coupled to the processor to sense a linear position of the corresponding linear translation stage;

the Θ rotational stage of the device mount includes a Θ position sensor electrically coupled to the processor to sense a Θ position of the Θ rotational stage;

the Φ rotational stage of the device mount includes a Φ position sensor electrically coupled to the processor to sense a Φ position of the Φ rotational stage;

the processor determines an angle of incidence of the pulses of laser light with the high-precision surface based on the predetermined surface design shape, the three orthogonal linear positions sensed by the three linear position sensors, the Θ position sensed by the Θ position sensor, and the Φ position sensed by the Φ position sensor; and

the processor controls the device mount to maintain the angle of incidence at substantially 0° as the beam spot is scanned over the portions of the high-precision surface that deviate from the predetermined surface design shape.

64. A laser machining system according to claim 37, wherein:

the Φ rotational stage of the device mount is a spindle motion stage; and

the processor controls the spindle motion stage to rotate the device about the Φ axis at a substantially constant angular rate, the constant angular rate being such that a scan rate of the beam spot over the high-precision surface is less than one half of the diameter of the beam spot times a repetition rate with which pulses of laser light irradiate the high-precision surface.

65. A laser machining system according to claim 37, wherein, the processor includes at least one of:

a general purpose computer;

a digital signal processor;

special purpose circuitry; or

an application specific integrated circuit.

66. A laser machining system according to claim 37, wherein the processor controls the pulse energy of the plurality of pulses of laser light and the diameter of the beam spot such that the ablation depth is in the range of about .01μm to 10μm.

67. A laser machining system according to claim 37, further comprising, an assist gas chamber enclosing the device mount.

68. A laser machining system according to claim 67, wherein, the assist gas chamber includes a transparent window to transmit the plurality of pulses of laser light.

69. A laser machining system according to claim 67, wherein, the assist gas chamber includes an assist gas jet to blow assist gas over the high-precision surface.

70. A laser machining system according to claim 37, further comprising, an assist gas jet to blow assist gas over the high-precision surface.

71. A multi-position in situ diagnostics apparatus for use with a laser machining system, the multi-position in situ diagnostics apparatus comprising:

a multi-position in situ diagnostics shuttle;

an objective lens mounted on the multi-position in situ diagnostics shuttle;

a forward-facing beam alignment camera mounted on the multi-position in situ diagnostics shuttle;

wherein, the multi-position in situ diagnostics shuttle is arranged such that;

in a first shuttle position, the objective lens is aligned in a beam path of the laser machining system to focus laser light of the laser machining system to a beam spot on a surface; and

in a second shuttle position, the forward-facing beam alignment camera is aligned collinear to the beam path and images the surface of the device corresponding to a location of the beam spot when the multi-position in situ diagnostics shuttle is in the first position to produce an alignment image for determining initial beam alignment of the laser machining system on the surface.

72. A multi-position in situ diagnostics apparatus according to claim 71, wherein:

the objective lens and the forward-facing beam alignment camera are mounted on the multi-position in situ diagnostics shuttle along a shuttle translation line that is substantially perpendicular to an axis of the beam path; and

the multi-position in situ diagnostics shuttle moves between the first shuttle position and the second shuttle position by translating along the shuttle translation line.

73. A multi-position in situ diagnostics apparatus according to claim 71, further comprising:

a backward-facing beam quality camera mounted on the multi-position in situ diagnostics shuttle;

wherein, the multi-position in situ diagnostics shuttle is arranged such that, in a third shuttle position, the backward-facing beam quality camera is aligned collinear to the beam path and images a cross-section of the plurality of pulses of laser light to determine beam quality.

74. A multi-position in situ diagnostics apparatus according to claim 73, wherein:

the backward-facing beam quality camera mounted on the multi-position in situ diagnostics shuttle along the shuttle translation line; and

the multi-position in situ diagnostics shuttle moves between the first shuttle position, the second shuttle position, and the third shuttle position by translating along the shuttle translation line.

75. A multi-position in situ diagnostics apparatus according to claim 71, wherein:

the objective lens includes an XY lens translation stage to align an axis of the beam path with a center of the objective lens when the multi-position in situ diagnostics shuttle is in the first shuttle position.

76. A multi-position in situ diagnostics apparatus according to claim 75, wherein:

the forward-facing beam alignment camera includes an XY camera translation stage to align the axis of the beam path with a center of the forward-facing beam alignment camera when the multi-position in situ diagnostics shuttle is in the second

shuttle position.

77. A multi-position in situ diagnostics apparatus according to claim 75, further comprising:

a backward-facing beam quality camera mounted on the multi-position in situ diagnostics shuttle;

wherein;

the multi-position in situ diagnostics shuttle is arranged such that, in a third shuttle position, the backward-facing beam quality camera is aligned collinear to the beam path and images a cross-section of the plurality of pulses of laser light to determine beam quality; and

the backward-facing beam quality camera includes an XY camera translation stage to align the axis of the beam path with a center of the backward-facing beam quality camera when the multi-position in situ diagnostics shuttle is in the third shuttle position.

78. An improved aspherical lens for use with short wavelength light, the aspherical lens comprising:

a lens material including;

a first light refracting surface having a first aspherical surface shape matching a predetermined first aspherical surface design shape with a first surface maximum deviation of less than about 1μm; and

a second light refracting surface opposite the first light refracting surface, the second light refracting surface having a second surface shape matching a predetermined second surface design shape with a second surface maximum deviation of less than about 1μm.

79. A lens according to claim 78, wherein:

first surface deviations of the first aspherical surface shape from the predetermined first aspherical surface design shape include traces of mechanical processing marks; and

second surface deviations of the second surface shape from the predetermined second surface design shape include traces of mechanical processing marks.

80. A lens according to claim 78, wherein the predetermined second surface design shape is aspherical.

81. An improved asymmetric lens for use with short wavelength light, the asymmetric lens comprising:

a lens material including;

a first light refracting surface having an asymmetric surface shape matching a predetermined asymmetric surface design shape with a first surface

maximum deviation of less than about 1μm; and

a second light refracting surface opposite the first light refracting surface, the second light refracting surface having a second surface shape matching a predetermined second surface design shape with a second surface maximum deviation of less than about 1μm.

82. A lens according to claim 81, wherein:

first surface deviations of the first asymmetric surface shape from the predetermined first asymmetric surface design shape include traces of mechanical processing marks; and

second surface deviations of the second surface shape from the predetermined second surface design shape include traces of mechanical processing marks.

83. A lens according to one of claims 78 or 81, wherein:

the first surface maximum deviation is less than about 0.1μm; and

the second surface maximum deviation is less than about 0.1μm.

84. A lens according to one of claims 78 or 81, wherein:

the first surface maximum deviation is less than about 0.05μm; and

the second surface maximum deviation is less than about 0.05μm.

85. A lens according to claim 81, wherein the predetermined second surface design shape is asymmetric.

86. A lens according to one of claims 78 or 81, wherein the lens material includes at least one of glass, sapphire, or plastic.

87. An improved compression mold for short wavelength aspherical lenses, the compression mold comprising:

a mold body formed of a mold material, the mold body including a mold surface having an aspherical mold surface shape matching a predetermined aspherical surface design shape with a mold surface maximum deviation of less than about 1μm.

88. A compression mold according to claim 87, wherein:

mold surface deviations of the aspherical mold surface shape from the predetermined aspherical surface design shape include traces of mechanical processing marks.

89. A compression mold according to claim 87, further comprising:

a release film formed on the mold surface of the mold body, the release film having a release surface opposite the mold surface;

wherein the release surface has an aspherical release surface shape matching the predetermined aspherical surface design shape with a release surface maximum deviation of less than about 1μm.

90. An improved compression mold for short wavelength asymmetric lenses, the compression mold comprising:

a mold body formed of a mold material, the mold body including a mold surface having an asymmetric mold surface shape matching a predetermined asymmetric surface design shape with a mold surface maximum deviation of less than about 1μm.

91. A compression mold according to claim 90, wherein:

mold surface deviations of the asymmetric mold surface shape from the predetermined asymmetric surface design shape include traces of mechanical processing marks.

92. A compression mold according to claim 90, further comprising:

a release film formed on the mold surface of the mold body, the release film having a release surface opposite the mold surface;

wherein the release surface has an asymmetric release surface shape matching the predetermined asymmetric surface design shape with a release surface maximum deviation of less than about 1μm.

93. An improved compression mold for microstructures, the compression mold comprising:

a mold body formed of a mold material, the mold body including a mold surface having a mold surface shape matching a predetermined surface design shape with a mold surface maximum deviation of less than about 1μm.

94. A compression mold according to claim 93, wherein:

mold surface deviations of the mold surface shape from the predetermined surface design shape include traces of mechanical processing marks.

95. A compression mold according to one of claims 87, 90, or 93, wherein the mold surface maximum deviation is less than about 0.1μm.

96. A compression mold according to one of claims 87, 90, or 93, wherein the mold surface maximum deviation is less than about 0.05μm.

97. A compression mold according to one of claims 87, 90, or 93, wherein the mold material includes at least one of: tungsten-carbide; sapphire; a solid state carbon material; Al_2O_3; Cr_2O_3; SiC; ZrO_2; Si_3N_4; TiN; TiC; BN; Ni; Cr; Ti; W; Ta; Si; glass; a cermet incorporating at least one of TiN, TiC, Cr_3C_2, or Al_2O_3; or an alloy incorporating at least one of Ni, Cr, Ti, W, Ta, or Si.

98. A compression mold according to claim 93, further comprising:

a release film formed on the mold surface of the mold body, the release film having a release surface opposite the mold surface;

wherein the release surface has a release surface shape matching the

predetermined surface design shape with a release surface maximum deviation of less than about 1μm.

99. A compression mold according to one of claims 89, 92, or 98, wherein the release surface maximum deviation is less than about 0.1μm.

100. A compression mold according to one of claims 89, 92, or 98, wherein the release surface maximum deviation is less than about 0.05μm.

101. A compression mold according to one of claims 89, 92, or 98, wherein the release film includes at least one of: nickel, titanium, niobium, vanadium, molybdenum, platinum, palladium, iridium, rhodium, osmium, ruthenium, rhenium, tungsten, and tantalum.

102. A compression mold according to one of claims 87, 90, and 93, wherein the mold surface of the mold body includes a damage layer of damaged mold material, the damage layer having a thickness of less than about 10nm.

103. A compression mold according to claim 102, wherein the damage layer is an oxide layer.

104. An improved release film for a compression mold, the release film comprising:

release film material formed on a mold surface of the compression mold;

wherein, a release surface of the release film material is opposite the mold surface and has a release surface shape matching a predetermined surface design shape with a maximum deviation of less than about 1μm.

105. A release film according to claim 104, wherein the release surface maximum deviation is less than about 0.1μm.

106. A release film according to claim 104, wherein the release surface maximum deviation is less than about 0.05μm.

107. A release film according to claim 104, wherein the release film material includes at least one of: nickel, titanium, niobium, vanadium, molybdenum, platinum, palladium, iridium, rhodium, osmium, ruthenium, rhenium, tungsten, and tantalum.